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SUMMARY

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PRINCIPLES OF PLANT GENETICS AND THEIR USE IN INCREASING FOOD PRODUCTION

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No. 719

PRINCIPLES OF PLANT GENETICS AND THEIR USE IN INCREASING FOOD PRODUCTION

C.4.1.

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SUMMARY

1. Applied genetics or plant breeding has been one of the most effective sciences available for increasing productivity of crop plants. Improved varieties, developed by application of genetic principles, provide increases in total yield of food, feed or fiber; reduce production losses caused by diseases, insects and other hazards; improve nutritive and industrial values of crops; facilitate introduction of the crop into new areas; and reduce production costs through greater efficiency of fertilizer usage, easier culture and harvest and adaptation to mechanization. Plant breeding provides short term results from use of superior local seed sources or introduced varieties and long term results through development of varieties specifically designed for local soil, climatic and use conditions. In less developed countries, improved varieties have the advantage of requiring, after the variety is developed, little capital outlay by the farmers. Furthermore, experience has shown that improved varieties lead the way to other improvements by the farmers in cultural practices, irrigation, fertilization, disease and pest control.

2. The first step in plant breeding is evaluation of existing materials, including indigenous varieties, farmer's seed lots, natural stands and introductions from other areas of the world. Such trials enable the breeder to make rapid improvements through identification of varieties that can be increased and distributed without further breeding. Extensive collections of the world germ plasm of various important crops are available in the United States and other countries.

3. Once suitable breeding materials have been identified, the breeding objectives have been clarified, and, if possible, progress has been made on increasing and distributing superior existing varieties, a more formal breeding program can be initiated. There are three basic steps in breeding, namely, (a) finding or developing suitable populations within which effective selection can be practiced, (b) selection, including evaluation of the selections, and (c) use of the selections to produce varieties for distribution to farmers.

4. In early stages of the program, indigenous varieties, farmer's seed lots, natural stands and introductions provide suitable populations within which effective selection is possible However, the plant breeder can make greatest ultimate progress by developing populations which have combinations of genes and gene frequencies permitting greatest progress by selection. By hybridization of carefully selected parents, presence of desired genes in the population can be assured. Frequencies of desirable genes may be increased by various mating systems including inbreeding, backcrossing, recurrent selection and reciprocal recurrent selection.

5. Success in breeding, once suitable source populations are available, is dependent upon effectiveness of selection. To maximize effectiveness of selection, it is necessary to reduce differential effects of environment to a minimum relative to genetic differences in the population. This may be accomplished by (a) special measures to assure as nearly as possible uniform environments for all plants in the population, (b) use of appropriate experimental designs to reveal differences, control and measure error and provide a valid estimate of significance of the differences, and (c) use of selection units appropriate to the characters for which selections are made. It is emphasized that one of the simplest and frequently neglected methods for reducing environmental effects is by good cultural practices, good stands and uniform fertilization. The selection unit to be used depends upon heritability of the important characters. For those with high heritability, effective progress can be made by selection of individual plants or clones. Conversely, for characters of low heritability, selection must be based upon a progeny test if it is to be effective. In the self-pollinated crops, the selection unit is normally the plant or its selfed progeny. In naturally cross-pollinated crops, selections usually are evaluated in some kind of hybrid combination. These include top crosses or polycrosses for evaluating general combining ability and diallel crosses and crosses with specific lines or clones to assess specific combining ability and to identify the best specific combinations.

6. Selections in naturally self-pollinated crops usually are increased through successive generations to become the varieties of commerce. In naturally cross-pollinated crops, selections are used in development of synthetic varieties or as parents of hybrids.

7. The importance of cooperation in plant breeding is stressed.

8. A breeding program cannot contribute to increased food production until seed of the improved varieties is generally available to the farmers. Procedures and organizations for orderly increase and distribution of such seed are required.

9. Breeders in developing countries usually will contribute most through use of conventional breeding methods. Usefulness of special methods such as radiation, interspecific gene transfer and polyploidy is restricted to particular situations and normally should not be used except as adjuncts to a strong breeding program.

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